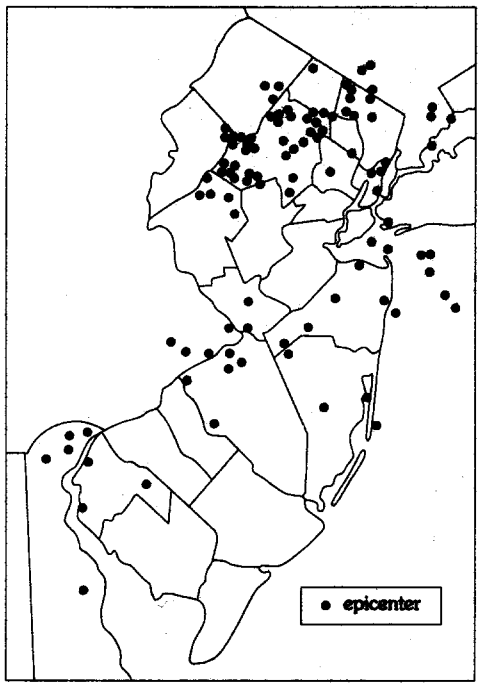
Earthquake Risk in New Jersey



"We felt a shock —
Was it an earthquake?"

New Jersey State Police
Office of Emergency Management

Department of Environmental Protection
Division of Science and Research
New Jersey Geological Survey

Federal Emergency Management Agency
Region II

1998

STATE OF NEW JERSEY
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Department of Law and Public Safety
Peter Verniero, *Attorney General*

Division of State Police
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Geological Survey
Haig F. Kasabach, *State Geologist*

Cover: Map showing earthquake epicenters in and near New Jersey, 1737-1990, and a question often heard when an earthquake is felt.

Earthquake Risk in New Jersey

by Daniel R. Dombroski, Jr.

What is an earthquake?

In New Jersey earthquakes usually occur when slowly accumulated strain within the Earth's crust is suddenly released along a fault. The energy from this movement travels as seismic waves along the ground surface and within the crust. The arrival of this released energy is felt as an earthquake.

How are earthquakes measured?

The measure of an earthquake's strength is expressed as magnitude, and is determined by using an instrument called a seismograph. Magnitude values are expressed according to a scale in which an increase of 1 represents a 10-fold increase in amplitude of the seismic wave. A 10-fold increase in amplitude represents about a 32-fold increase in energy released for the same duration of shaking. The best known magnitude scale is one designed by C.F. Richter in 1935 for west coast earthquakes.

In New Jersey, earthquakes are measured with seismographs operated by the Lamont-Doherty Earth Observatory of Columbia University and the Delaware Geological Survey.

An earthquake's intensity is determined by observing its effects at a particular place on the Earth's surface. Intensity depends on the earthquake's magnitude, the distance from the epicenter, and local geology. These scales are based on reports of people awakening, felt movements, sounds, and visible effects on structures and landscapes. The most commonly used scale in the United States is the Modified Mercalli Intensity Scale (page 2), and its values are usually reported in Roman numerals to distinguish them from magnitudes.

Past damage in New Jersey

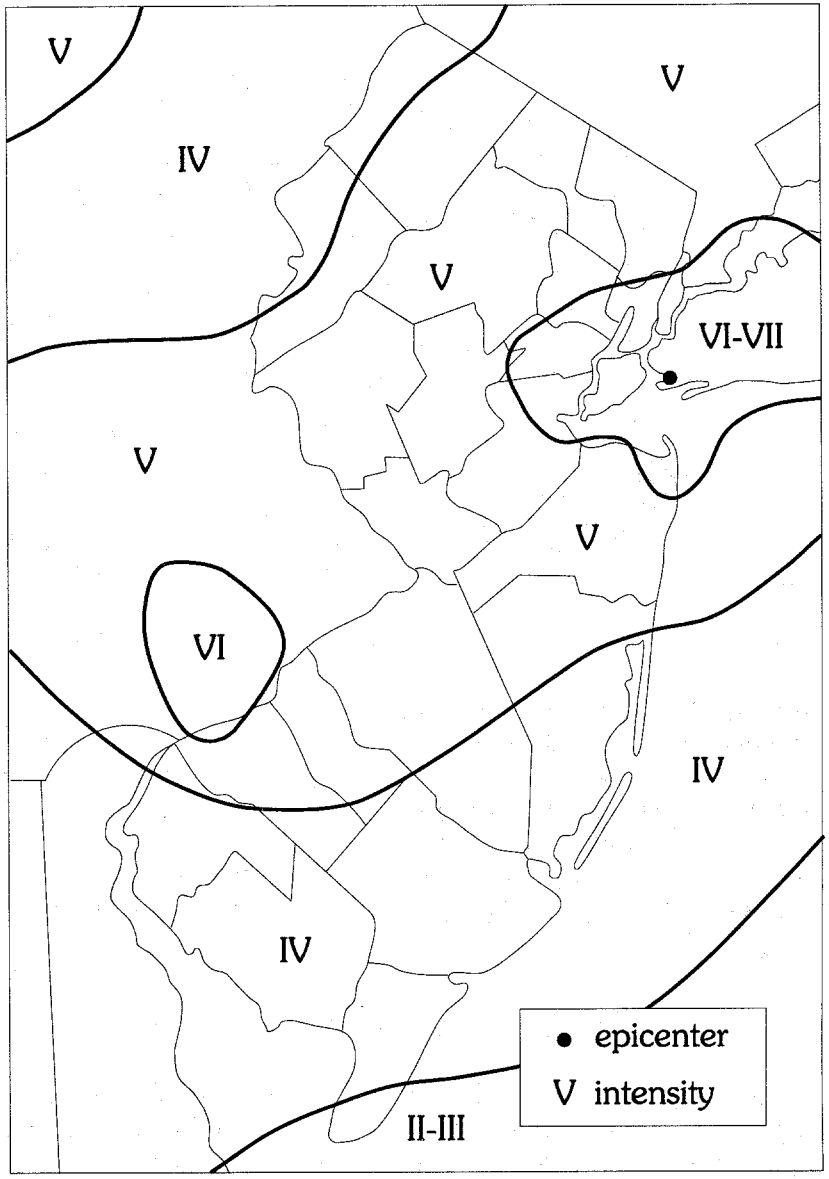
New Jersey doesn't get many earthquakes, but it does get some. Fortunately most are small. A few New Jersey earthquakes, as well as a few originating outside the state,

Modified Mercalli Intensity Scale of 1931[1]

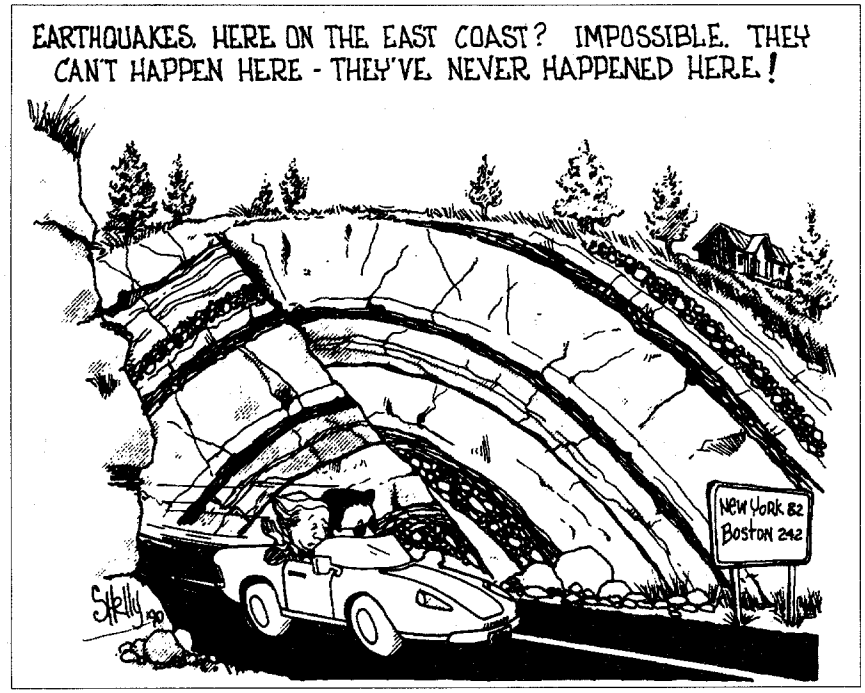
Mercalli Intensity	Equivalent Magnitude[2]	Effects
I	1.9	Not felt except by a very few under especially favorable circumstances.
II	2.5	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended object may swing.
III	3.1	Felt quite noticeably indoors, especially on upper floors of building but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	3.7	During the day, felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V	4.3	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	4.9	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	5.5	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars.
VIII	6.1	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.
IX	6.7	Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	7.3	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	7.9	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	8.5	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

1 Abridged (Wood and Neumann, 1931). Wording is that of Wood and Neumann. Effects on cars, trucks and buildings built according to modern standards may be different.

2 Magnitude values were estimated using the formula: magnitude = 1.3 + (0.6 maximum intensity).



Modified Mercalli intensity estimates for the New York earthquake of 1884.



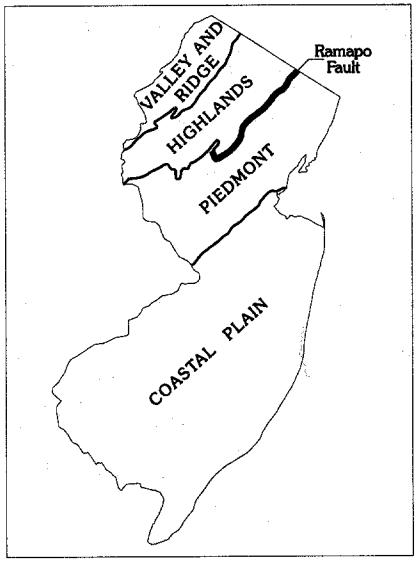
have produced enough damage to warrant the concern of planners and emergency managers.

Damage in New Jersey from earthquakes has been minor: items knocked off shelves, cracked plaster and masonry, and fallen chimneys. Perhaps because no one was standing under a chimney when it fell, there are no recorded earthquake-related deaths in New Jersey. We will probably not be so fortunate in the future.

Area Affected by Eastern Earthquakes

Although the United States east of the Rocky Mountains has fewer and generally smaller earthquakes than the West, at least two factors increase the earthquake risk in New Jersey and the East. Due to geologic differences, eastern earthquakes effect areas ten times larger than western ones of the same magnitude. Also, the eastern United States is more densely populated, and New Jersey is the most densely populated state in the nation.

Geologic Faults and Earthquakes in New Jersey



Physiographic provinces of New Jersey, and location of the Ramapo Fault.

Although there are many faults in New Jersey, the Ramapo Fault, which separates the Piedmont and Highlands Physiographic Provinces, is the best known. In 1884 it was blamed for a damaging New York City earthquake simply because it was the only large fault mapped at the time. Subsequent investigations have shown the 1884 earthquake epicenter was actually located in Brooklyn, New York, at least 25 miles from the Ramapo Fault. However, numerous minor earthquakes have been recorded in the Ramapo Fault Zone, a 10 to 20 mile wide area lying adjacent to, and west of, the actual fault.

More recently, in the 1970's and early 1980's, earthquake risk along the Ramapo Fault received attention because of its proximity to the Indian Point, New York, Nuclear Power Generating Station.

East of the Rocky Mountains (including New Jersey), earthquakes do not break the ground surface. Their focuses lie at least a few miles below the Earth's surface, and their locations are determined by interpreting seismographic records. Geologic fault lines seen on the surface today are evidence of ancient events. The presence or absence of mapped faults (fault lines) does not denote either a seismic hazard or the lack of one, and earthquakes can occur anywhere in New Jersey.

Damaging Earthquakes Felt in New Jersey

Location	Year	Magnitude[1]	Intensity[2] Max. / in NJ	Comments
New York City	1737		VII / VII	Chimneys down in New York City. Felt in Boston, Massachusetts and Philadelphia, Pennsylvania.
Cape Ann, Massachusetts	1755	6.0	VIII / IV	Chimneys and brick buildings down in Boston. Its tsunami grounded boats in the West Indies.
West of New York City	1783		VII / VII	Felt from New Hampshire to Pennsylvania.
New Madrid, Missouri	1811 - 1812	8.0 - 8.8	XII / IV-V	Four great earthquakes. Changed course of Mississippi River. Town of New Madrid destroyed. Loss of life low due to sparse settlement. Damage in Chicago.
New York City	1884	5.5	VII / VII	Toppled chimneys in New York City and New Jersey. Cracked masonry from Hartford, Connecticut to West Chester, Pennsylvania. Felt from Maine to Virginia, and eastern Ohio.
Charleston, South Carolina	1886	7.7	X / IV	Sixty killed. Over 10,000 chimneys down.
New Jersey Coast	1927		VII / VII	Several chimneys down from Asbury Park to Long Branch.

1 Richter Scale

2 Modified Mercalli Scale

Frequency of Damaging Earthquakes in New Jersey

Records for the New York City area, which have been kept for 300 years, provide good information for estimating the frequency of earthquakes in New Jersey.

Earthquakes with a maximum intensity of VII (page 6) have occurred in the New York City area in 1737, 1783, and 1884. One intensity VI, four intensity V's, and at least three intensity III shocks have also occurred in the New York area over the last 300 years.

The time-spans between the intensity VII earthquakes were 46 and 101 years. This, and data for the smaller-intensity quakes, implies a return period of 100 years or less, and suggests New Jersey is overdue for a moderate earthquake like the one of 1884.

Earthquake Frequency Worldwide[1]

Description	Magnitude	Average Annually
Great	8 and higher	1 per year
Major	7 - 7.9	18
Strong	6 - 6.9	120
Moderate	5 - 5.9	800
Light	4 - 4.9	6,200 (estimate)
Minor	3 - 3.9	49,000 (estimate)
Very Minor	2 - 2.9	1,000 per day
--	1 - 1.9	8,000 per day
Microearthquakes	less than 1	60,000 per day

1 Based on observations since 1900. Modified from United States Geological Survey, internet address: wwwneic.cr.usgs.gov/neis/general/handouts/faq.html

Buildings and Earthquakes

The 1995 earthquake in Kobe, Japan, is an example of what might happen in New Jersey in a similar quake. It registered a magnitude 7.2 on the Richter scale and produced widespread destruction. But it was the age of construction, soil and foundation condition, proximity to the fault, and type of structure that were the major determining factors in the performance of each building. Newer structures, built to the latest construction standards, appeared to perform relatively well, generally ensuring the life safety of occupants.

New Jersey's building code has some provisions for earthquake-resistant design. But there are no requirements for retrofitting existing buildings -- not even for unreinforced masonry structures that are most vulnerable to earthquake damage. Housing of this type is common in New Jersey's crowded urban areas. If an earthquake the size of New York City's 1884 quake (magnitude 5.5) were to occur today, severe damage would result. Fatalities would be likely.

Structures have collapsed in New Jersey without earthquakes; an earthquake would trigger many more. Building and housing codes need to be updated and strictly enforced to properly prepare for inevitable future earthquakes.

How to Prepare for an Earthquake

Supplies

- Maintain emergency supplies of food, water (at least one gallon per day per person), prescribed medicines, etc., sufficient for three days.
- Rotate these with normal stocks to keep supplies fresh.
- Replace water every 6 months.

Emergency items

- Emergency items to have on hand should include:
  - Fire extinguishers
  - First-aid supplies and manual
  - Battery-powered radio
  - Flashlights with extra batteries.
    (Replace or rotate batteries periodically)
  - Nonelectric can opener

Secure unstable furniture and other items

- Secure unstable furniture and heavy items that might fall in a quake (book cases, files, shelving, TV's, computers, vases, etc.).
- Put heavy and large objects on lower shelves.
- Store glass, china and bottled foods in low, closed cabinets with latches.
- Heavy pictures and mirrors should be hung away from beds, chairs and couches.
- Tightly fasten overhead light fixtures.
- Strap water heaters and furnaces to walls, because the plumbing is not strong enough to support them in an earthquake. A broken gas pipe could lead to a fire.
- Keep pesticides, herbicides and flammable items in closed, latched cabinets on bottom shelves.

Identify safe places inside and outside

- Under sturdy furniture like a heavy table or desk.
- Against an inside wall.
- Away from glass that might shatter (windows, mirror, pictures) or where heavy furniture like bookcases could fall.
- Locate places outdoors away from buildings, trees, telephone and electrical lines, overpasses, or elevated roadways.

What to do
During a Strong Earthquake

Indoors

- Move away from windows, glass doors, furniture or other objects that might fall.
- Get under a sturdy table, or under a doorway of an interior wall.
- Stay in the building unless it is clearly unsafe, or you are told to leave. Leaving a building during the shaking of an earthquake is very dangerous because objects can fall on you.
- Use stairs. Elevators may lose power or fall.

Outdoors

- Move away from buildings (glass and debris may fall).
- Move away from trees, utility poles, overhead electric wires.
- Avoid highway underpasses, and other structures that might collapse.

In a car

- Drive to (or stay in) open areas away from danger of falling objects, power lines, etc.
- Vacate bridges, tunnels and underpasses.
- Watch traffic, other drivers may be disoriented, or out of control.
- Once in an open area, stay in your car.

What to do
If You Think You Feel an Earthquake:

Ask your neighbors if they felt it too.
Check with your local police.
Call your local newspapers and radio stations
or the
New Jersey Geological Survey:
(609) 292-2576

What to do
After an Earthquake

Expect and Check

- Expect aftershocks. They cause additional damage and can collapse weakened structures.
- Expect to be on your own for some time, perhaps two days or more.
- Check for injured or trapped. Render assistance and first aid as needed.
- Check for gas or smoke odors.
- Check for building structural damage and general safety.

Remember

- Flipping an electric switch causes sparks that will trigger explosions around gas leaks, as will cigarettes, candles and matches.
- Use flashlights, they are safe.
- Remain calm, and beware of panic in crowded places.
- Open closet and cupboard doors cautiously.
- Clean up spills of hazardous liquids, such as medicines and flammables.
- Clean up broken glass and other debris.
- Inspect chimneys carefully. Damage could lead to fire.
- Leave gas-main on unless you smell gas.
- Leave electric-main on unless you know the lines are damaged and unsafe.
- If you turn off a utility-main after a disaster, only the utility company is allowed to turn it on again -- after they have determined it is safe. This may leave you without heat or light for several days.

Water

- Water can be obtained from canned vegetables, melted frozen foods or ice, hot-water-heater drain valves (even if water main is off), and from toilet tanks (not bowls).

Pets

- There may be significant behavioral changes in pets after an earthquake. Cats and dogs that are normally friendly and quiet may become aggressive or defensive. Watch them closely. Leash dogs or place them in a fenced yard.

Sources of Earthquake Information:

New Jersey Geological Survey
Haig F. Kasabach, State Geologist
P.O. Box 427
Trenton, NJ 08625-0427
phone: (609) 292-2576 or 292-1185
FAX: (609) 633-1004
Internet: http://www.state.nj.us/dep/njgs/

New Jersey State Police
Kathy Lear
Office of Emergency Management
Operational Planning Bureau
Box 7068 River Road
West Trenton, NJ 08628-0068

U.S. Geological Survey
Phone: 1-800-USA-MAPS
Internet: http://www.usgs.gov/

County Offices of Emergency Management
see your local phone book's blue-pages for number.

New Jersey Geological Survey earthquake publications:

- **Earthquakes in New Jersey,** Dombroski, Daniel R., Jr., 1973, revised 1977, 30 p., 1 illus.
- **Catalog of New Jersey Earthquakes through 1990**, Dombroski, Daniel R., Jr., 1992, 30 p., 2 illus. (GSR 31).

available from:

New Jersey Department of Environmental Protection
Maps and Publication Sales Office
P.O. Box 438
Trenton, NJ 08625-0438
phone: (609)777-1038

Glossary

Amplitude - A seismic wave amplitude is how far the ground shakes up and down or side to side. To determine magnitudes, the amplitudes measured by seismographs are adjusted for distance of the seismograph to the epicenter.

Earthquake- A sudden motion or trembling in the Earth caused by the abrupt release of strain, slowly accumulated by faulting, or volcanic activity.

Epicenter - The point on the surface directly above the focus.

Fault - A fracture-surface in the Earth's crust along which sliding motion has taken place in the past. See also, fault line.

Fault Line - The trace of a fault on the surface, frequently exposed by erosion. Often simply called a fault.

Focus or Hypocenter - The location of an earthquake within the crust.

Highlands - a relatively large area of elevated or mountainous land standing above adjacent low areas.

Intensity - The severity of the effects of an earthquake. The intensity of an earthquake is different at different locations. Intensities are given in Roman numerals to distinguish them from magnitudes.

Magnitude - A measure of an earthquake's size. Magnitude is determined by various methods. Magnitude is an index of the amplitude of the seismic waves created by an earthquake. An increase of one magnitude unit represents a ten-fold amplitude increase. This ten-fold amplitude increase represents about a 32-fold energy increase, for the same duration of shaking (larger quakes generally last longer, releasing even more energy).

Modified Mercalli Intensity - The intensity scale most commonly used in the United States. (see page 2)

Physiographic province - A region with similar geologic structure and history, and whose features and landforms differ significantly from that of adjacent regions.

Piedmont - an area lying or formed at the base of a mountain or mountain range.

Richter Magnitude - The first widely used magnitude scale. It was developed by Charles F. Richter for west-coast earthquakes.

Return Period or Recurrence Rate - The average amount of time between earthquakes of similar size and location. They are determined from our short 300-year historical record. Return periods of the larger, infrequent, earthquakes can be estimated from that of the smaller ones, and sometimes from geologic clues in sediments that were disturbed by ancient shocks. Return periods are shorter in the West than the East, and also shorter for smaller earthquakes. A return period is an average, and does not imply that earthquakes happen on any schedule.

Seismic - caused by an earthquake

Seismograph - An instrument that detects, magnifies, and records vibrations of the Earth, especially earthquakes

Tsunami - (Japanese for "harbor wave") A sea-wave caused by an earthquake. It has a very low profile in deep water, but grows vertically (up to 50 feet or more) in the shallow water near land. It often "breaks", like a huge surf-wave. Popularly called a "tidal wave".